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I have been unable, up to this time, to secure from our Mexico roads or from Nicaragua or Panama any reliable statement as to the comparative elevations of the two oceans, but I believe there can be no appreciable difference except it be local affected by contour of coast or possibly by winds and ocean streams. See letters from the Chief Geographer and Supt. C. & G. Survey, below:

DEPARTMENT OF THE INTERIOR, UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, April 18, 1885.

Mr. H. V. Hinckley, Office Engineer A. T. & S. F. R. R., Topeka, Kansas—DEAR SIR: If there is any difference in level between the Atlantic and Pacific oceans, it is too small to be indicated by levels of such a character as those run by our inter-oceanic canal expeditions. I have not learned anything concerning this point from the work now progressing upon the Isthmus of Panama. I feel, however, confident that the difference, if any, is very small. Very truly yours, HENRY GANNETT,
Chief Geographer U. S. G. S.

U. S. COAST AND GEODETIC SURVEY, WASHINGTON, June 26, 1885.

H. V. Hinckley, C. E., Topeka, Kansas—DEAR SIR: I have taken great interest in your important letter of the 23d, relating to the difference of level between the Atlantic and Pacific oceans. I trust that you will print your study in detail in the Journal of the American Society of Civil Engineers, and I will be very glad to print it likewise in the Coast Survey Report. The agreement of the several values is certainly unexpectedly close. I nevertheless do not think that the difference of the mean level of the oceans will be found so large by accurate operations. That which you give for San Francisco would, of course, be extremely acceptable. I do not think there can be any such thing as rotational difference of level between the two oceans, but the mean value of *what we are able to observe by means of spirit or water levels is the resultant of the constant forces, and, whatever may be the figure of equilibrium, it is just that which the level indicates.* When we observe a difference, then, it must be owing to dynamic effects of currents and winds. I have thus found the level of the Gulf of Mexico, in the neighborhood of the Balize, to be about forty (40) inches higher than that of the Atlantic ocean at Sandy Hook. That such an elevation must exist is plain enough, from the fact that the water runs from the Gulf of Mexico into the Atlantic ocean; but how much it is, is a question that must be solved by accurate leveling, and a verification is still in progress.

We have not yet extended our line of levels of precision to the Pacific ocean, but will proceed with it in the autumn. I do not know the difference of level between the two oceans at any point. I have always understood that the levels for the Panama Railroad showed that there was no appreciable difference between mean tides. . . . I shall be glad to hear from you again on the subject.

Yours truly, J. E. HILGARD, *Supt. U. S. C. & G. S.*

So that for the present I shall contend that my elevations are correct, and that the corrections of Mr. Gannett, in his 1884 edition of "Dictionary of Elevations," upon the A. T. & S. F. system, are unmerited, even though his precise information to the contrary warrants, on his part, the corrections he now makes. Therefore the question of sea elevations in Kansas must remain "at sea" to the extent of from 1 to 15 feet, or even more, depending on the locality, until the "levels of precision" shall cross the continent, or perhaps till I may earlier obtain checks enough from Texas and Mexico ports to prove the correctness of my apparently very correct results.

NATURAL GAS IN EASTERN KANSAS.

BY ROBERT HAY, U.S.G.S.

[N. B.—The paper with this title which was read at the Emporia meeting was much longer than the following. The introductory part, relating to the development of natural gas in Pennsylvania and elsewhere, has been almost altogether omitted, the more scientific part remodeled, and some additional facts given which became known only a little while before going to press. The paper as read at Emporia appears almost in its entirety in the Fifth Biennial Report of the State Board of Agriculture, whose widespread distribution will bring it within the reach of nearly all the citizens of the State.]

A single company at Pittsburgh, Pa., has a capital of five million dollars invested in procuring and distributing for use the new fuel named usually natural gas. Altogether, the natural gas companies of Pennsylvania employ an aggregate capital of more than twenty millions of dollars. At Wheeling in West Virginia, Findlay in

Hancock county, Ohio, and other places, the work done by means of natural gas is enormous, and is increasing. This gas, like petroleum or rock oil, comes from the bowels of the earth. It may be properly named *rock gas.* It is obtained from drilled wells, some of which are over three thousand feet in depth. The strata which yield the gas are more or less porous, like those which yield the rock oil. They are mostly sandstones, and as the oil beds are known as "oil sands," so those which yield gas are known as "gas sands." The porous sandstones, some of which are coarse-grained, are not the sources but only the reservoirs of the fluids they contain. The source is the decomposition of organic matter — mainly vegetable — with which certain other formations are charged to a greater or less extent. These other formations are the dark-colored shales, and the so-called "black slate," and the seams of coal, which under the conditions of their deposit and existence, including the enormous pressure of hundreds or thousands of feet of superincumbent rocks, give out their fluids — water, oil, and gas — to the porous beds above or below them. Gas and oil are, as would be expected, often in a porous rock *above* the shale-bed source. Water is always as low as it can get. The water mostly associated with oil and gas is salt water. Oil wells usually have some gas; gas and brine wells have some oil.

The term "gas sand" is used so commonly that it has become the equivalent of the more general term "gas rock," and as such has been used where the containing bed is not sandstone but limestone. In Ohio the Trenton limestone of the Lower Silurian age has at a depth of 1,200 feet yielded gas and oil. If the rock is porous and has an impervious covering of clay-shale or clay, it will hold these fluids. The writer has treated a small piece of compact Permian limestone thus: It was dried about to what it would be by outdoor exposure in dry weather. After carefully weighing it, it was immersed for twenty-four hours in coal oil — the ordinary lamp oil of commerce. Taken out, it was allowed to drain for an hour, and the wetness was all wiped off. It was then carefully re-weighed. The result was as follows:

Weight *before* immersion, 103.5 drams.
Weight *after* immersion, 104.5 drams.

This shows a quantity of oil absorbed in one day under ordinary atmospheric pressure, amounting to nearly *one per cent.* of the total weight of the stone. The writer has seen both sandstones and limestones much more highly charged with oil than this. When an impervious covering is over such porous rock, and hundreds or thousands of feet of superincumbent rock formations give their enormous pressure to force the gas or oil into the rock pores as fast as it is formed in nature's laboratory, such porous rocks become vast storehouses of these valuable fuels. As we have said, the two fluids are usually found together, though one or the other may preponderate to such a degree as to cause the other to be but slightly regarded. But we shall now speak more definitely of *rock gas.*

The geological horizons at which rock gas has been found in Pennsylvania, West Virginia and Ohio are in the Lower Coal Measures, and thence downward to the Lower Silurian. The upper horizons are below the Pittsburgh Coal; an important intermediate horizon is the Berea Grit, in the Waverley Series, and the lowest is the Trenton Limestone.

The force of the gas when the drill of the prospecter has tapped the porous reservoir is sometimes such as to throw out the heavy tools used, and when ignited, to send a flame forty feet high. The pressures measured, and estimated where measurement was impossible, show the equivalents of from fifteen to fifty atmospheres. These great pressures have caused much waste of gas, much leakage from pipe joints, and consequent danger from explosions. On the other hand, the great pressures have made it possible to pipe the gas to great distances, and the danger has stimulated invention, so that perfectly tight joints are now made. Pittsburgh receives gas from distances of from twelve to thirty miles, and Buffalo has just begun to have a supply from a distance of ninety miles.

In Miami county, Kansas, small quantities of oil have been seen in springs and wells from the date of the earliest settlements, and borings have been made from 1862 to the present time. It was not, however, till 1883 that a strong flow of gas was obtained. Now the Paola Gas Company, of which B. Miller, Esq., is president, has drilled four wells, of which three are now yielding a steady supply of *rock gas.* These wells are situate on the Westfall farm, N.E. quarter of section 16, T. 17, R. 24, seven miles east of the city of Paola. They substantially have the same level at the surface, and reach the *gas sand,* which here is a sandstone, at a depth of three hundred feet. One of the wells pierces this sand, and shows its thickness to be 35 feet, and above and below it are dark-colored beds, which, being laminated and jointed in their structure, are by the miners called "slates." The gas is piped seven and a half miles into the city of Paola, where it is used as fuel to steam engines, bakers' ovens, heating-stoves, and also to some extent as an illuminant in the stores of the city. At two of the wells the pressure of the gas is 66 lbs. to the square inch, at the other well it is under fifty.

Within three miles of the Westfall wells, at the small town of Louisburg, a well 325 feet deep gives a supply of gas which is utilized for heating and lighting Gunsolus's Hotel. Another company is drilling nearer Paola.

At Wyandotte not less than six wells have been drilled, which yield gas and some oil. They give the gas all apparently from the same horizon, which is about 340 feet below the level of the Kaw bottom. Unfortunately, some of the records of these drillings have been lost, and others are not available. The gas of three of these wells, owned by Mr. Ryas and Messrs. Northrop, is being used for heating steam boilers, and it is not improbable that gas from these sources and new wells will be much more extensively used. Over the border, in Kansas City, Mo., a number of wells are yielding gas which is being utilized both as an illuminant and for fuel in dwelling houses, by Messrs. Tobener and Dr. Ridge, and on the outskirts of the city by Mr. J. N. Dietz for burning lime. The wells at Wyandotte and Kansas City form one group, but unfortunately the drill records of none of those utilizing the gas are available for a proper comparison. The pressure from the Ryas (brickyard) well is 150 lbs. to the inch, and it displaces ninety per cent. of the coal formerly used for an engine of forty horse power.

In Linn county, about two miles east of LaCygne, gas has been issuing from the ground from a period "beyond which the memory of man runneth not back to the contrary." It is not marsh gas, but rock gas, and around its flame Indians have had their assemblies. Through the enterprise of Mr. T. McCarthy, who has leased the land, a well has been bored 180 feet deep, and a continuous supply of gas at a considerable pressure is now blowing off. Owing to lack of capital this fine supply is not being utilized. A mineral well 125 feet deep, at Mound City, owned by Mr. T. Ellwood Smith, yields a steady but not very copious supply of gas. Another well, owned by Mr. E. M. Adams, of greater depth, also yields gas, which it is intended to use at an early date. At Pleasanton and Blue Mound borings have been made, with no remunerative result yet.

In Crawford county a small quantity of gas was found at a depth of 173 feet, in the mineral well owned by the city of Girard. At Pittsburg a larger supply is being obtained, at a depth of 163 feet, and will be immediately utilized. At a much higher horizon, at a depth of 45 feet, in the northwest of the county, some oil and a bubbling as of gas has been found in a well east of Hepler.

In Labette county borings have been made near Parsons without result, but at Mound Valley there is a well 700 feet deep which yields gas at depths of 203 and 449 feet. The lower depth gives the strongest gas. It is of such force and volume as to raise the salt water, which enters at 277 feet, up to the surface, so that it is a flowing well. Owing to doubts relating to the title to the land, this supply is being allowed to run to waste.

In Allen county the well-known mineral well at Iola has always yielded some gas, which at times has been utilized. It enters with salt water in a crevice of 20 inches deep, with black bituminous shale above and below, at a depth of 625 feet. In the same county, north by east from Moran, unused gas is blowing off from a well one hundred feet deep, in a valley drained by the headwaters of the Little Osage.

Some gas was found in the deep well at Independence, in Montgomery county. At near Liberty, in the same county, a shaft sunk for coal gives off from a black shale, at a depth of 98 feet, a gas which from its odor would be called coal gas.

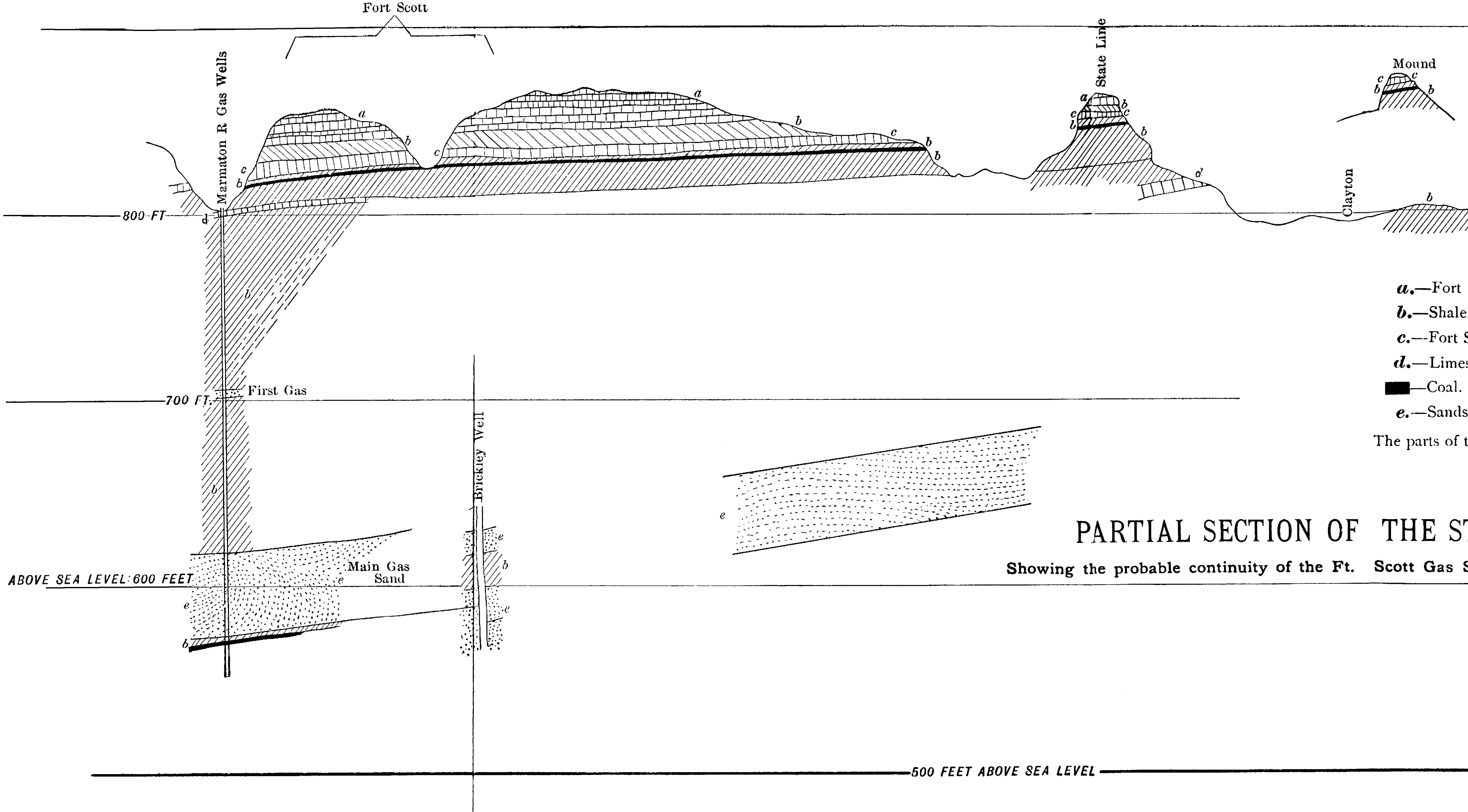
In Bourbon county, on the banks of the Marmaton river, on the Stewart farm just southwest of the city of Fort Scott, gas has been known to escape from the ground for more than a quarter of a century. Now, the Economy Fuel Company (Major Knapp, manager) has leased the land, and drilled five wells. Three of these are yielding a strong supply, which appears to have about the pressure and qualities of the Paola gas. It is piped to the town through six-inch mains, and, as one of the wells supplies a fair illuminant, it is used both for heating and lighting dwelling houses, the principal hotels, the street-car barn, and many other places. With other wells judiciously located, there can be no doubt but that the supply of this gas will long be an important factor in the progress of the rising city of Fort Scott. The facts, that the gas has been escaping for years, and that the pressure is not nearly so great as in the eastern States, suggest that the supply is likely to be permanent. This is probably true at Paola, also, and more certainly at LaCygne.

Five miles west of Fort Scott, gas is bubbling in a well about 70 feet deep. In the eastern part of the city itself the same is occurring in a well 100 feet in depth. East-northeast from Fort Scott, seven miles north of Deerfield, in Vernon county, Mo., a similar shallow well gives out gas. At other places on each side of the State line, small quantities of gas have been thus observed, and also of oil.

There is now much activity in prospecting for gas at places where it has already been found, and at other places removed from the belt when its presence is assured. Among the latter places may be mentioned Quenemo, Ottawa, and Wichita. That it may possibly be found at some places not yet tested, will be seen from a consideration of the geology of the localities where the experimental drillings have been successful.

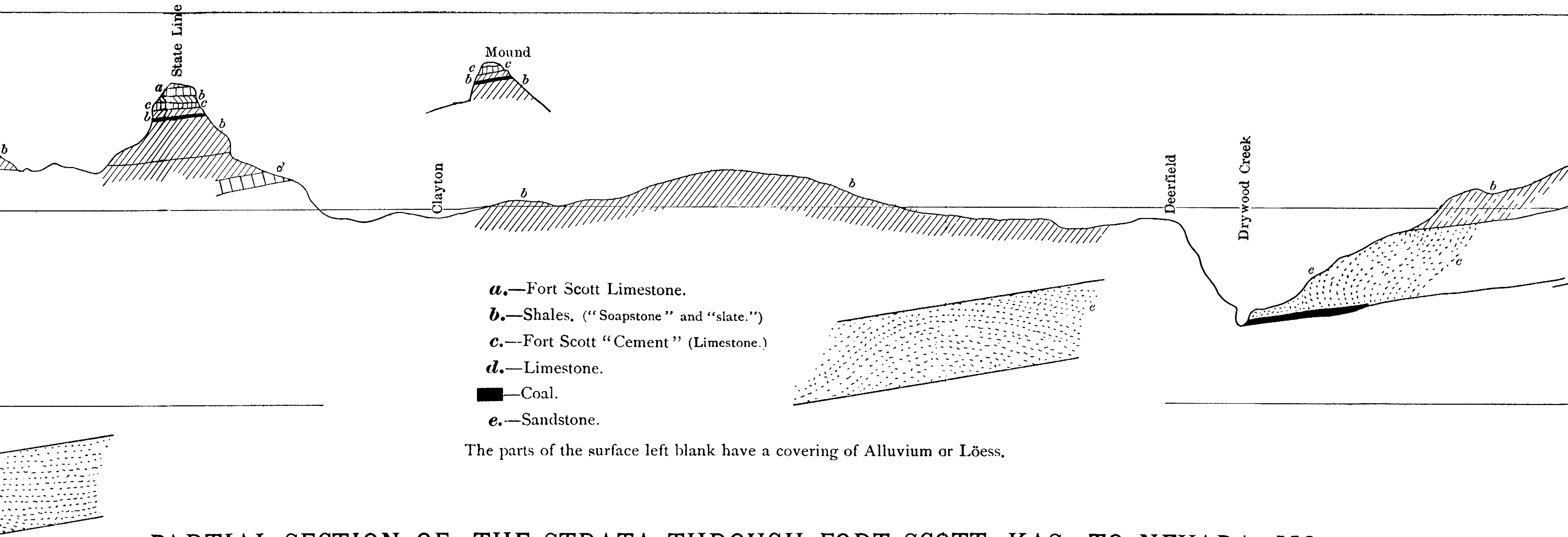
The rock gas obtained thus far in Kansas belongs geologically to the lower part of the Lower Coal Measures. Besides the gas wells at Fort Scott, there have been made four other borings at that place, the records of which have been preserved. These four go to greater depths than the gas wells. They are: The Brickley well, south of the city; the Walburn well, near the northeast corner; the Point well, and the artesian well. About the city the Marmaton valley and several smaller ravines are very steep and show ledges of rock. Going east, much erosion has laid bare successive formations. From an examination of these exposures, and a study of the drill records of the well-borings, the geology of the rock gas of this region can be made out fairly well. In the higher parts of the city a coarse fossiliferous limestone is found, in layers of from four to eight inches thick, with a total thickness about the city of from five to fifteen feet. This is followed by formations thus:

1. The layer limestone, (average) 10 feet.
2. Black slate, including a thin coal seam, 6 feet.
3. Heavy bed of concretionary hydraulic limestone, called locally "the cement rock," 5 feet.



PARTIAL SECTION OF THE ST

Showing the probable continuity of the Ft. Scott Gas S

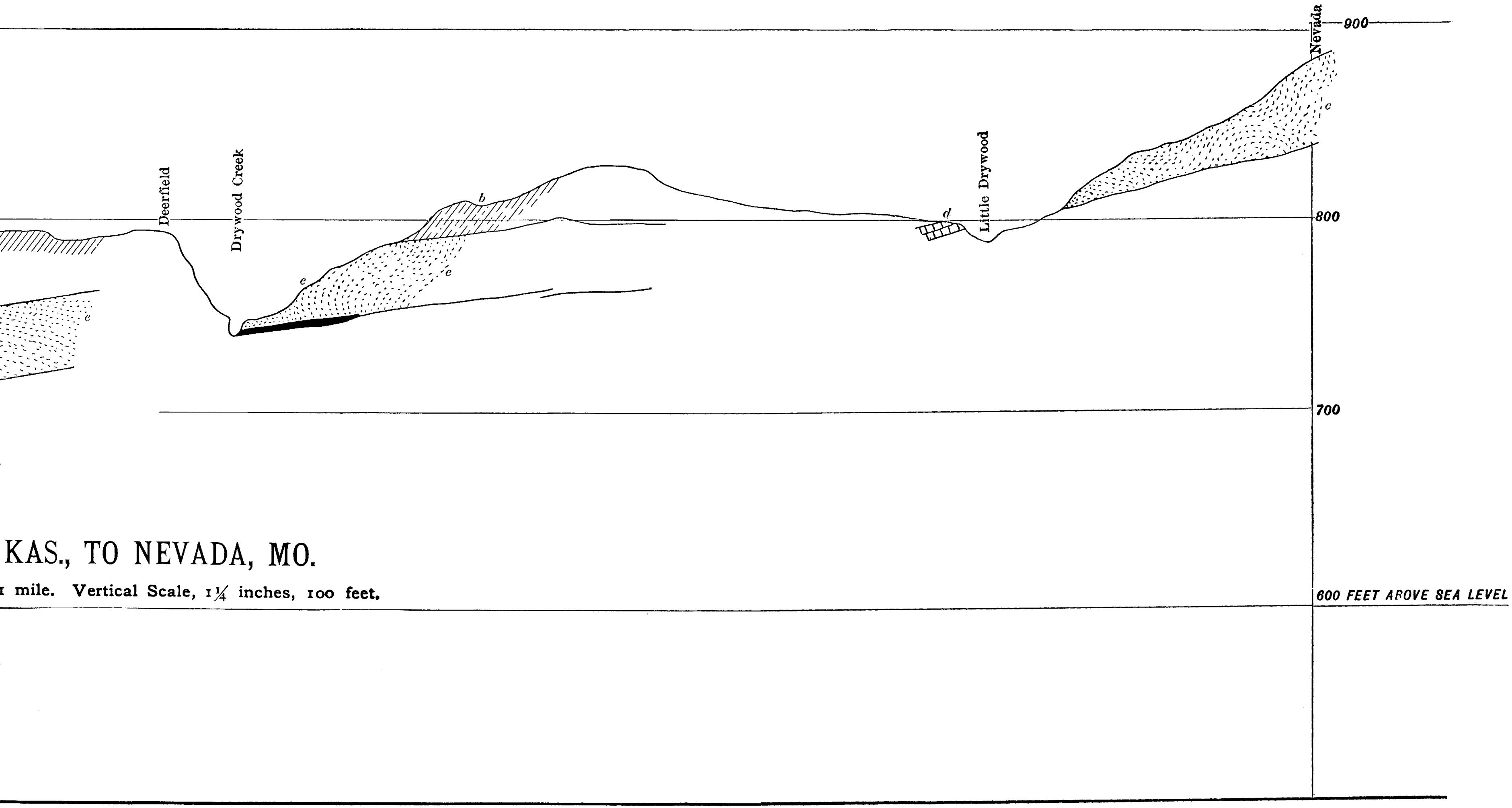

State Line
Mound
Clayton
Deerfield
Drywood Creek
a
b
c
d
e
a.—Fort Scott Limestone.
b.—Shales. ("Soapstone" and "slate.")
c.—Fort Scott "Cement" (Limestone.)
d.—Limestone.
■—Coal.
e.—Sandstone.
The parts of the surface left blank have a covering of Alluvium or Löess.

PARTIAL SECTION OF THE STRATA THROUGH FORT SCOTT, KAS., TO NEVADA, MO.

Showing the probable continuity of the Ft. Scott Gas Sand easterly. Horizontal Scale, 1 inch to 1 mile. Vertical Scale, 1¼ inches, 100 feet.

BY ROBERT HAY.

FEET ABOVE SEA LEVEL



KAS., TO NEVADA, MO.

1 mile. Vertical Scale, 1¼ inches, 100 feet.

4. "Slate," 2 to 8 feet.
5. Fort Scott coal, 18 inches to 2 feet.
6. Shales, arenaceous and argillaceous, about 50 feet.
7. Limestone, dark, 2 to 3 feet.
8. Shales, with occasional hard, thin beds of sandstone and limestone, 175 feet.
9. Sandstone, MAIN GAS SAND, 42 feet.

A thin "gas sand" is met with about midway between 7 and 9, and gas comes off coal or slate some forty feet below 9. "Black slate" and thin coal are immediately beneath the main gas sand. In the Brickley well the sandstone includes an intercalation of thirty feet of shale, and gives a much greater total thickness. The *gas sand* is about 245 feet below the "cement" rock, which is a very conspicuous feature in the topography of the district. (See geological section.)

Proceeding east from Fort Scott, the layer limestone, thickening considerably to the eastern limit of the city, is rapidly eroded and totally disappears about the region of the State line; the "cement" rock fails not far beyond, and shales are the outcrop of ravines as far as Drywood creek, on the east of which a sandstone shows itself, with a thin coal seam at the base. Around Nevada, which is much higher than the mouth of Drywood, this sandstone has great development, in places reaching over fifty feet thick. This is the formation which the Missouri geologists have named the Clear Creek Sandstone. In many places it is redolent of oil. The upper surface of this sandstone in Nevada is about fifty feet higher than the layer limestone at Fort Scott, but at its outcrop on Drywood creek it is fully fifty feet below that limestone. Proceeding west, buried under shales, it yields the gas in the shallow well north of Deerfield; and buried still further, it becomes the MAIN GAS SAND of Fort Scott. An examination of the section on the opposite page will make this easily understood, and an understanding of this will make the prospecting for gas in that region more a matter of certainty than without such understanding. A *complete* examination of the Paola gas region has not yet been made, but the tendency of the evidence so far is toward assuming the main gas sand there to belong to the same Clear Creek horizon. The tendency is also toward regarding the Pittsburg (Crawford county) gas as from the same sandstone; and the gas sand at Mound Valley is from very nearly the same horizon.

The two shallow wells in and near Fort Scott yield their gas from shale, probably locally arenaceous, not far below the cement bed.

West of Fort Scott, and stretching from north to south of Bourbon county, is a sandstone plateau. Its horizon is immediately above the layer limestone before mentioned, which in its wide extension develops great thickness (40 to 60 feet) as the Pawnee Limestone. The sandstone plateau yields valuable flagstones at Gilfillan, Redfield, and some miles east of Porterville, and also just over the line in Crawford county, south of Hyattville. These flagstones are frequently bituminous, and it is this sandstone, under cover of limestone and shale, that yields the oil on Mr. Pease's farm east of Hepler. It is a still higher sandstone under cover which yields the gas north by east of Moran, in Allen county.

In prospecting for oil and gas in Pennsylvania, theories as to the geological structure have been used to work from. The summit of an unbroken anticlinal slope would appear to promise the best position for a reservoir of gas in any suitable stratum, and it would appear that the bottom of a synclinal slope would be apt to have more water than gas or oil. Though exceptions to this rule are found, it may be taken for granted that it is true where other conditions do not modify the general structure. In Kansas, no pronounced anticlinals have yet been observed, though it cannot be doubted that there are well-defined synclinals, though of but moderate depression. All the principal gas wells are in valleys. Those at Fort Scott and Wyandotte are in the most important valleys of their respective regions—valleys whose erosion long antedates the Glacial epoch. It would appear that these valleys represent slight synclinal folds, and that gas with less water may well be be expected further from their median regions. The main structural fact of the gas region of Kansas is the steady monoclinal dip to the west and north. This varies in amount; hence there are gentle local anticlines and synclines, but scarcely enough to alter the effect of the general monoclinal dip. This dip is fairly represented as to its westing in the section before given. It appears to be more than geologists have been prepared for, but it certainly decreases in amount in Allen county. If the *amount of the dip*, together with *variation of dip*, in local anticlinals or synclinals, plays any greater part in the supply of gas, then greater supplies will not probably be obtained much further west. It remains, however, to be noted, that in the valley of Fall river there are very decided changes of dip, whose limits have not been defined; and the wide region between the Marmaton, the Kaw and the Arkansas rivers needs much more examination before an opinion adverse to the occurrence of gas could be sustained — especially as it is known that dark, even black shales, and many sandstones, occur at higher horizons, which, dipping west, become sufficiently buried beneath shales and limestones; and an arenaceous limestone in Woodson county is heavily charged with oil.

It is probable that the Fort Scott oil well (Walburn's) obtains its supplies from the very highest beds of the subcarboniferous formations, probably Keokuk limestone, from 400 to 440 feet deep. This suggests that shales and sandstones at greater depths may yield the fluid fuels. According to Prof. St. John, the Silurian rocks are pierced by the deep wells at Pittsburg and Girard, and this would appear to be the same in the Brickley well at Fort Scott, whose total depth is 996 feet. Properly exploited, there may yet from deeper wells than the Brickley, be taken large supplies of gas or oil.

[N. B.—Small quantities of gas have been observed in Mitchell, Dickinson and Washington counties, and it is not improbable the Cretaceous and Lignitic formations may yield some supplies in central and western Kansas.—As this goes to press, another well at Paola yields gas at much higher pressure. It was tested to 105 lbs. to the square inch, but leakage prevented its full power being reached.—R. H.]

MISCELLANEOUS CHEMICAL NOTES.

BY PROF. E. H. S. BAILEY, LAWRENCE, KANSAS.

I.

ON THE PRESENCE OF BARIUM, STRONTIUM AND LITHIUM IN THE MINERAL WATERS OF KANSAS.

At a former meeting of the Academy, attention was called to the occurrence of Bromine and Iodine in our mineral waters, and the author predicted that other comparatively rare elements might be found. Prof. Mayberry reports the presence of Lithium in many of the wells of Cleveland, and suggests that greater care be exercised in testing for rare elements.* The water from a well in Miami county, Kansas, has been recently examined. It proved to be a saline well containing over 300 grains of solid matter per gallon. It was especially interesting since it contained a relatively large amount of lithium, with appreciable quanties of strontium, and of borax.

II.

MINERAL OIL FROM FORT SCOTT.

A sample of mineral oil from a well 431 feet deep, at Fort Scott, has been examined in the State University laboratory. The well is said to yield four barrels a

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*American Association for the Advancement of Science. Buffalo. 1886.